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Health Information Tracking via Mobile Applications for Individuals with Chronic Health Conditions

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Health Information Tracking via Mobile Applications for Individuals with Chronic Health Conditions

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Report

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Abstract

Health Information Tracking via Mobile Applications for Individuals with Chronic Health Conditions

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By 2015, 149 million Americans are expected to be living with chronic health conditions (Anderson 2010). This number is expected to continue rising. Many chronic health conditions require those living with them to perform health self-management tasks on a regular basis. Nearly two in every five adults with one chronic condition and three out of every five adults with at least two chronic conditions track their health information.

This paper investigates the use of mobile applications and the need to develop applications specifically designed for individuals living with chronic health conditions. Pew data are used to determine who is tracking their health information and how they are tracking it. Results from this analysis show that individuals with chronic health conditions have 69% greater odds of tracking health information than individuals who do not live with chronic conditions. Additionally, those with chronic conditions are 254% more likely than those without chronic conditions to track health indicators that are not

related to diet, weight or exercise. These individuals are not, however, using mobile applications to track their health information. People with chronic health conditions have higher probabilities of tracking health information on paper or in their heads than their probability of tracking via a mobile application. However, the probability that individuals track health information via mobile apps increases when analyzing a subset of the population who own smartphones.

After learning more about individuals with chronic conditions and their health information tracking habits, several mobile health applications are reviewed. The reviews of these applications include the features offered by the applications and their price. The paper concludes with several recommendations for developing and disseminating mobile health tracking applications to individuals with chronic conditions, as well as suggestions for future research.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

By 2015, 149 million Americans are expected to be living with at least one chronic condition such as hypertension, diabetes, asthma, and heart disease (Anderson 2010). This number is expected to increase to about half of all Americans, or 171 million people, by 2030 (Anderson 2010). With an aging population, these numbers are expected to continue growing, as chronic conditions are even more prevalent among older adults. In 2006, 90.7% of Americans over 65 years of age suffered from at least one chronic condition (Anderson 2010). Furthermore, the prevalence of individuals 65 years of age and older who are living with multiple chronic health conditions increased by about eight percentage points over a 10-year period, from about 37% in 2000 to 45% in 2010 (Freid, Bernstein, and Bush 2012).

Individuals with chronic conditions use the health care system far more than those who do not have chronic conditions. Approximately 84% of total health care spending in the United States can be attributed to individuals with chronic health conditions; this is an increase of six percentage points since 1997 (Anderson 2010). It should be noted that not all of this increase in health care spending is directly related to chronic health conditions. However, individuals with multiple chronic conditions are more likely to have unnecessary or preventable hospitalizations, duplications in testing, and more types of prescriptions, which can also lead to increased health care spending (Anderson 2010). This increase in health care usage can be seen in the percentage of health care spending attributed to this group, with individuals who have more than one chronic condition accounting for 66% of overall health care spending (Anderson 2010).

The ability to perform health self-management tasks is essential for many individuals who suffer from chronic conditions. According to a recent survey by Pew,

about 40% of individuals with one chronic condition and 62% of individuals with two or more chronic conditions track health-related information (Fox and Duggan "Tracking for Health" 2013). In that same study it was found that 34% of individuals monitor health information via paper methods and about 49% track health information in their heads (Fox and Duggan "Tracking for Health" 2013). Moving users to mobile apps instead of paper or non-written tracking methods could increase treatment adherence and improve their ability to self-manage their conditions (Aitken and Gauntlett 2013). An additional benefit of using mobile applications for self-health monitoring is the potential to reduce healthcare spending as a whole, given the ability of the mobile application to provide individuals with costly chronic conditions an improved means to track and in turn better manage their health.

Smart phones and mobile applications have become part of the everyday lives of many Americans. The ubiquity of this technology could be used to help individuals with chronic conditions manage their health and take steps toward alleviating their condition. Mobile applications that track an individual's health are very popular, with 16,275 available on the market in October 2013 (Aitken and Gauntlett 2013). Health apps are predominately used by individuals tracking their diet, weight, and fitness activities. In contrast, only 12.2% (1,980) are for specific therapy areas, most of which are targeted at users with chronic health conditions (Aitken and Gauntlett 2013). Furthermore, only 27 apps are targeted at senior users despite their increased likelihood of having chronic conditions (Aitken and Gauntlett 2013). This indicates that, although individuals 65 years of age and older are more likely to have chronic conditions, only about 0.2% of mobile health apps on the market are targeted toward seniors.

This paper attempts to determine who is tracking their health information and how they are tracking it, what features might be attractive in a mobile health application

targeted toward an individual with one or more chronic conditions, and what strategies might be taken to encourage individuals, specifically seniors, with chronic conditions to use mobile health applications. Pew data from 2012 are used to investigate how individuals in the United States with chronic conditions track their health information. Several popular mobile health-tracking applications are then reviewed in terms of features offered, benefits to those with chronic conditions, and cost. Finally, several recommendations are made for developing and disseminating mobile health applications to individuals with chronic conditions. These recommendations include avenues for future research in regard to wearable technology and employer-based incentives for health tracking.

Chapter 2: Literature Review

A literature review was performed to help inform the research within this paper. The topics examined were which health indicators people with chronic conditions track, smart phone adoption, mobile application usability and how mobile applications have affected self-management of health conditions.

PREVALENT CHRONIC CONDITIONS IN THE UNITED STATES

Individuals suffer from a wide variety of chronic conditions. These chronic conditions also vary by age. Younger individuals tend to suffer from different chronic conditions than older Americans. Overall, the most common type of chronic condition is hypertension, which affects 33.3% of individuals with a chronic condition (Anderson 2010). For individuals over the age of 65, 60% of those with chronic conditions suffer from hypertension (Anderson 2010). However, only 30% of those with chronic conditions between the ages of 18 and 64 have hypertension, and hypertension is not a common chronic condition among children ages zero to 17 (Anderson 2010). Cholesterol disorders are also prevalent between both groups. About 41% of individuals over 65, and 20% of individuals 18 to 64 report a cholesterol disorder (Anderson 2010). Americans ages 65 and older report suffering from arthritis, heart disease and eye disorders as the next most common chronic conditions, with 28%, 25% and 23% of individuals reporting these conditions, respectively (Anderson 2010). However, respiratory diseases (19%) and diabetes (12%) are the third and fourth most common chronic conditions to affect individuals between 18 and 64 (Anderson 2010). Furthermore, individuals who are 65 and older are more likely to report suffering from multiple chronic conditions then those who are 45 to 64 or 20 to 44 years of age, with 73.1%, 42.8% and 16.8% of each group reporting more than one chronic condition, respectively (Anderson 2010).

SMART PHONE ADOPTION

Mobile applications require the use of a smartphone or tablet device. The prevalence of these technologies and their usage is important to consider when creating a mobile health application. In recent years, there has been a dramatic increase in the number of people using smartphones. In May 2013, 56% of American adults indicated they own smartphones; this is an increase from 46% of adults who said they own smartphones in February 2012 (Smith 2013). This trend is expected to continue into the future (Rogowsky 2014.). Approximately 39% of individuals ages 55 to 64 and 18% of individuals 65 and over own smartphones (Smith 2013). However, it should be noted that about 29% of those ages 65 to 69 and 21% of individuals 70 to 74 own smartphones, compared with 5% of seniors 80 and over ("Older Adults and Technology Use" 2014). This appears to indicate that younger seniors are far more likely to use smartphones. Furthermore, as the baby boomers continue aging into the 65 and over group, it is expected that the percentage of seniors who use smartphones will increase. The ubiquity of smartphones and the growing market increase the potential for return on investment for mobile application developers.

MOBILE APPLICATION USABILITY

The usability of a mobile application is critical to its success. Mobile application developers and the users face a number of limitations that might not occur on other types of programs. About 48% of users found that mobile applications are difficult to read and use (Martínez-Pérez et al. 2013). It is likely that the percentage of individuals who find mobile applications difficult to read and user would be even higher among seniors due to the relatively low number of seniors who own smartphones. Small screens and keyboards make viewing and inputting data more difficult than it would be on a traditional desktop computer (Martínez-Pérez et al. 2013). Input forms should be optimized for web,

allowing users to scroll or tab to enter their information instead of typing on a keyboard (Tan 2011).

Streamlining applications for mobile devices is also important. Developers concentrating on the user interfaces (UI) of mobile applications should remember to keep the key features of the app in the forefront (Cerejo 2012). For example, when creating an app where individuals track their blood glucose levels, make this the featured item and place other optional features less prominently. Along with prominently displaying key features, navigation within the mobile application should be kept to a minimum. Navigation in a mobile application should be broad and narrow, not deep, meaning fewer clicks should be used to get the user where they need to go. Additionally, a path for navigating back to the previous location should be made clear to the user (Cerejo 2012).

USING MOBILE APPLICATIONS TO IMPROVE TREATMENT ADHERENCE

Successful treatment and management of health conditions often depend on the patient adhering to the prescribed treatment regimen. Smartphones and mobile applications are becoming increasingly popular tools for improving patient adherence. Automated reminders are one example of how mobile applications are used in this context. Some ways in which reminders have been used are to remind individuals to take medications and to remind users to track different health indicators (Dayer et al. 2013). One study found that medication reminders helped improve patients' medication adherence by 7% ("Mobile Phone App Helps Patients" 2011). Another idea for how mobile applications can be used to engage and motivate individuals with chronic conditions. Using mobile applications to encourage users to continue complying with their treatment or to provide them with information on their condition and how to

properly manage it may increase compliance by increasing the individual's knowledge and motivation (Reach 2009).

Chapter 3: Data Analysis

Pew data were used to better understand who is tracking their health information, what they are tracking, and how they are tracking it. Independent variables that were considered include age, income, education, sex, race, and the presence of a chronic condition. Logistic regressions were used to estimate the likelihood that individuals would track their health information and use a specific type of tracking device. Profiles of individuals were created to determine the predicted probability that individuals would track information or track it in a specific way. Following the data analysis is a discussion of how the results can be applied to helping individuals with chronic health conditions track their health information. Limitations within the data are also addressed.

DESCRIPTION OF DATA

In 2012, the Pew Research Center's Internet & American Life Project sponsored the 2012 Health Survey (Fox and Duggan "Methodology" 2013). The survey was conducted from August 7 to September 6, 2012, and 3,014 adults across the United States participated. Princeton Survey Research Associates International performed the phone-based interviews. Both landline phone and cell phone random digit dial (RDD) samples were used to collect responses in both Spanish and English (Fox and Duggan "Methodology" 2013.

Sex	Frequency	Percentage
Male	1,098	45.9%
Female	1,294	54.1%
Age	**Frequency**	**Percentage**
18 to 29	394	16.5%
30 to 49	737	30.8%
50 to 64	681	28.5%
65+	580	24.3%
Average Age	**50**	
Education Level	**Frequency**	**Percentage**
No high school diploma	209	8.7%
High school diploma	635	26.6%
Some College	637	26.6%
College+	911	38.1%
Household Income Level	**Frequency**	**Percentage**
Less than $30,000	857	35.8%
$30,000 to $49,999	515	21.5%
$50,000 to $99,999	622	26.0%
$100,000+	398	16.7%
Race/Ethnicity	**Frequency**	**Percentage**
White	1,495	62.5%
Black	406	17.0%
Hispanic	346	14.5%
Other	145	6.0%

TABLE 3.1: Demographic Descriptive Statistics

For the purposes of this paper, the data were cleaned to include only participants who responded to variables of interest. The variables used for cleaning were age, race, income, education and self-reported health. If a respondent did not respond to one of these variables or did not know the answer, their response was removed. This cleaning process reduced the sample size to 2,392 responses from the original 3,014 responses. The demographic descriptive statistics for the sample are displayed in Table 3.1.

In addition to the demographic statistics from Table 3.1, descriptive statistics for the additional variables of interest were obtained. These variable include the ownership

of a smartphone, the presence of a chronic condition, if an individual tracks health information, what health indicators individuals track, and what types of devices individuals use to track their health information. The descriptive statistics for these variables can be found in Table 3.2.

Variable	Percentage
Has Smartphone	45.1%
Has Chronic Condition	49.1%
Tracks Health Indicator	71.8%
Tracks Weight, Diet or Exercise	64.8%
Tracks Other Health Indicator	37.1%
Uses Paper to Track Health Indicator	26.7%
Has Mobile Health App	9.1%
Uses Mobile App to Track Health Indicator	4.1%
Uses Computer Program to Track Health Indicator	3.9%
Uses Website to Track Health Indictor	1.3%
Tracks Health Indictor in Head	34.2%
Uses Medical Device to Track Health Indicator	6.6%

TABLE 3.2: Descriptive Statistics – Variables of Interest

DISCUSSION OF VARIABLES

It is important to understand the variables of interest within this data in order to understand the results. The demographic information is straightforward; however, a few of the additional variables need to be clarified. The variables that will be discussed are has chronic health condition, uses paper to track health indicator, tracks health indicator in head and tracks other health indicator.

The chronic condition variable is included in all of the data analysis in this paper. This variable represents several types of chronic conditions. These chronic conditions include diabetes; high blood pressure; asthma, bronchitis, emphysema or other lung

conditions; heart disease, heart failure or heart attack; cancer; or other chronic health conditions.

The tracking variables of using paper and tracking health information in one's head are used as dependent variables within the data analysis. Tracking on paper indicates that individuals write down their health information on a piece of paper. This does not necessarily mean they have a specific form or journal where they record this information. The tracks in head variable includes health information that people just remember and do not physically input or write down the information anywhere. For example, if someone were to weigh himself or herself from time to time, remember the weight and not write it down anywhere, they would be tracking this health-related information in their head. Finally, the tracks other health indicator is used as both a dependent and independent variable within the analysis. This option might include individuals who track blood pressure, blood glucose levels, menstrual cycles, sleep patterns, headaches, mood and other health indicators that are not related to weight, diet and exercise.

CROSS-TABULATIONS OF DATA

Simple cross-tabulations of the data were performed to better understand the breakdown of individuals within the sample. Figure 3.1 shows that 78.0% of respondents with a chronic health condition and 65.7% of respondents without chronic conditions tracked their health information.

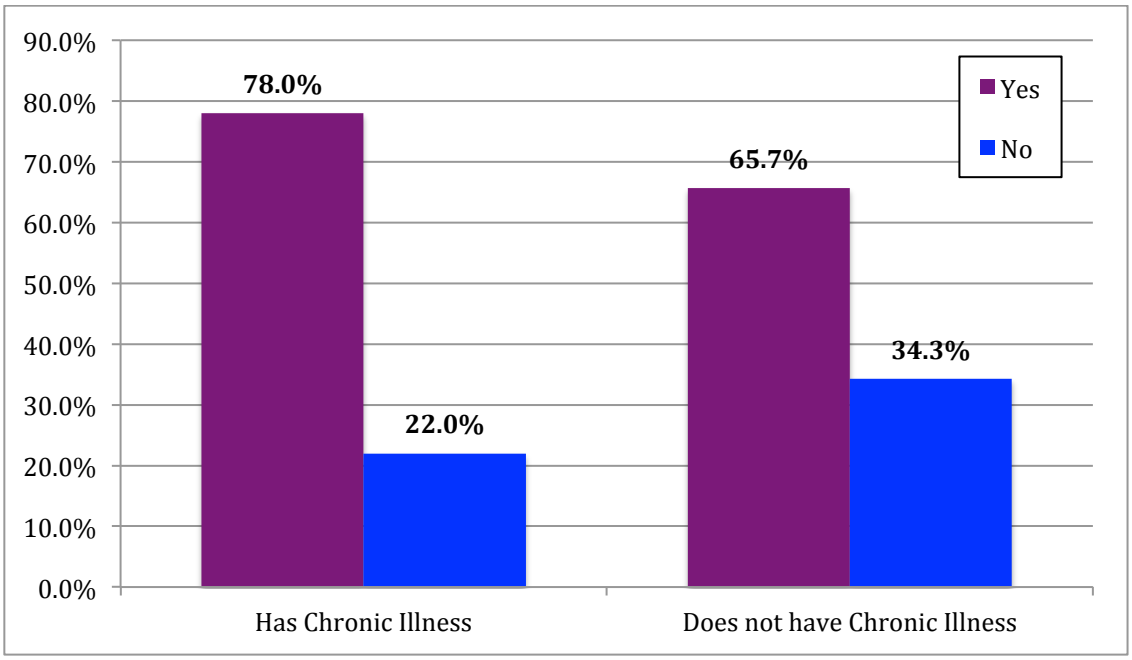

FIGURE 3.1: Tracks Health Information - Cumulative

Cross-tabulations were used to determine if those respondents with chronic conditions were tracking different information than respondents who do not have chronic health conditions. Figure 3.2 is a cross-tabulation of individuals tracking weight, diet or exercise information. The results indicate that about the same percentage of individuals were tracking this information in each group. About 66.6% of respondents with at least one chronic condition and 63.1% of individuals who do not have a chronic condition track weight, diet or exercise information.

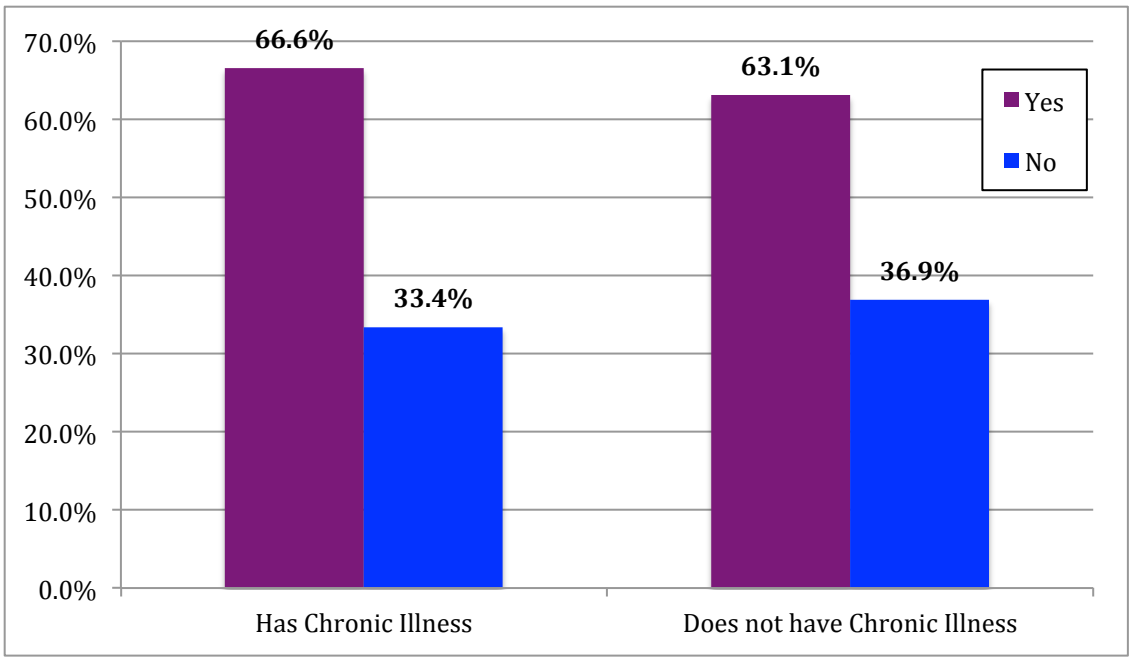

FIGURE 3.2: Tracks Diet, Weight or Exercise

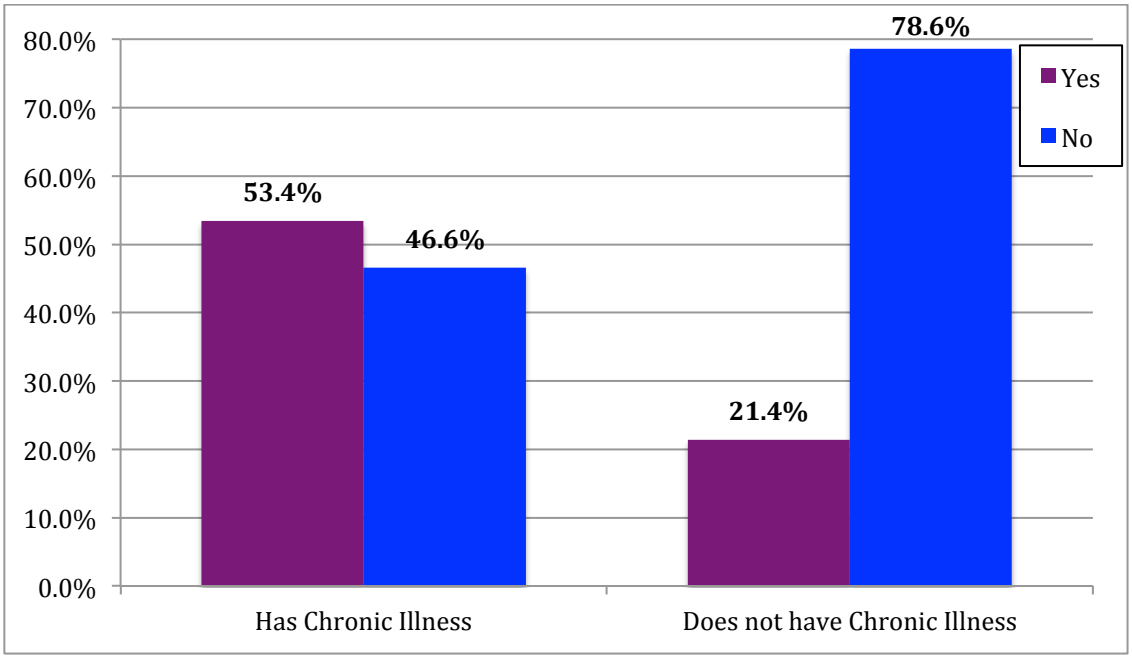

FIGURE 3.3: Tracks Other Health Indicator

The numbers for individuals who track other health indicators are not as similar as those who track diet, weight or exercise information. According to Figure 3.3, approximately 53.4% of individuals with chronic conditions and only 21.4% of respondents without chronic condition track other health information. This cross-tabulation indicates that individuals with chronic conditions face different health information tracking needs than those without chronic conditions.

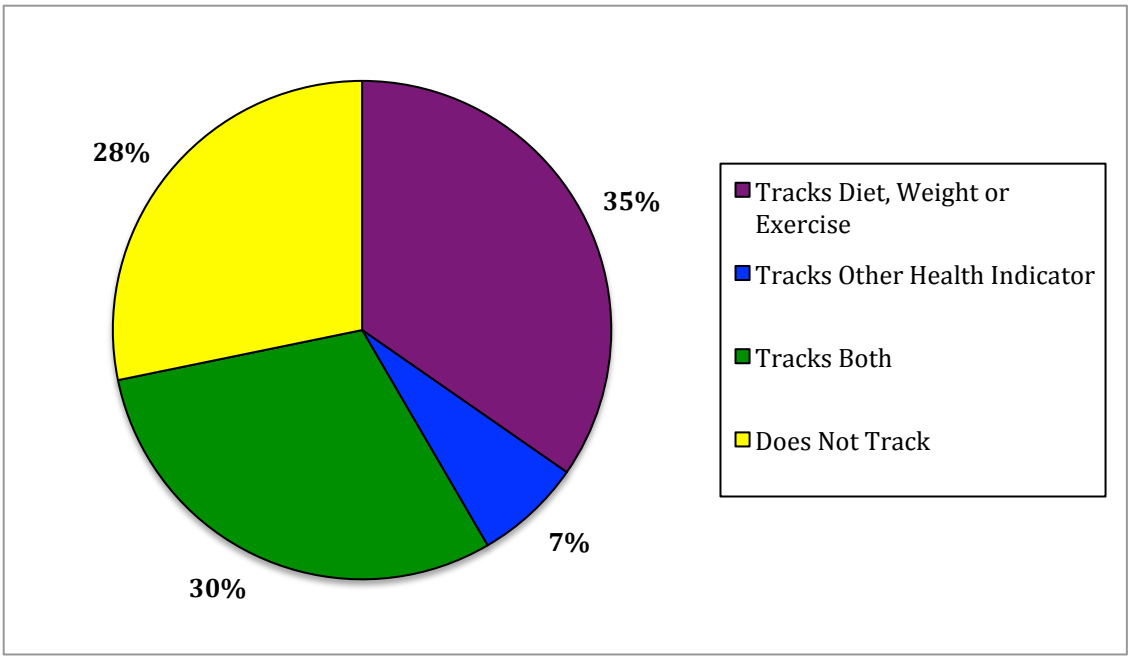

FIGURE 3.4: Nature of Health Tracking

A large number of individuals reported tracking track diet, weight or exercise information along with other health indicators. Figure 3.4 shows that about 35% of respondents track only diet, weight or exercise information, while only 7% track strictly other health indicators. Thirty percent of respondents both track other health indicators and diet, weight or exercise information. However, 28% of respondents do not track

anything. With the large amount of overlap, it is likely that many individuals with chronic conditions track diet, weight or exercise information in addition to other health indicators.

A second series of cross-tabulations were performed to discern which health tracking devices individuals tended to use. Tracking devices included in these cross-tabulations were recording results on paper, a mobile application, a medical devices, and tracking results in one's head. Figure 3.5 shows the devices used by individuals according to whether or not they indicated living with a chronic condition. The two most popular methods of tracking were in one's head and by paper. Forty-four percent of individuals with chronic conditions tracked health information on paper, while 41.9% tracked information in their heads. Individuals who do not have chronic conditions were more likely to track information in their heads than via paper, with 54.4% and 28.9% of individuals reporting using these methods, respectively.

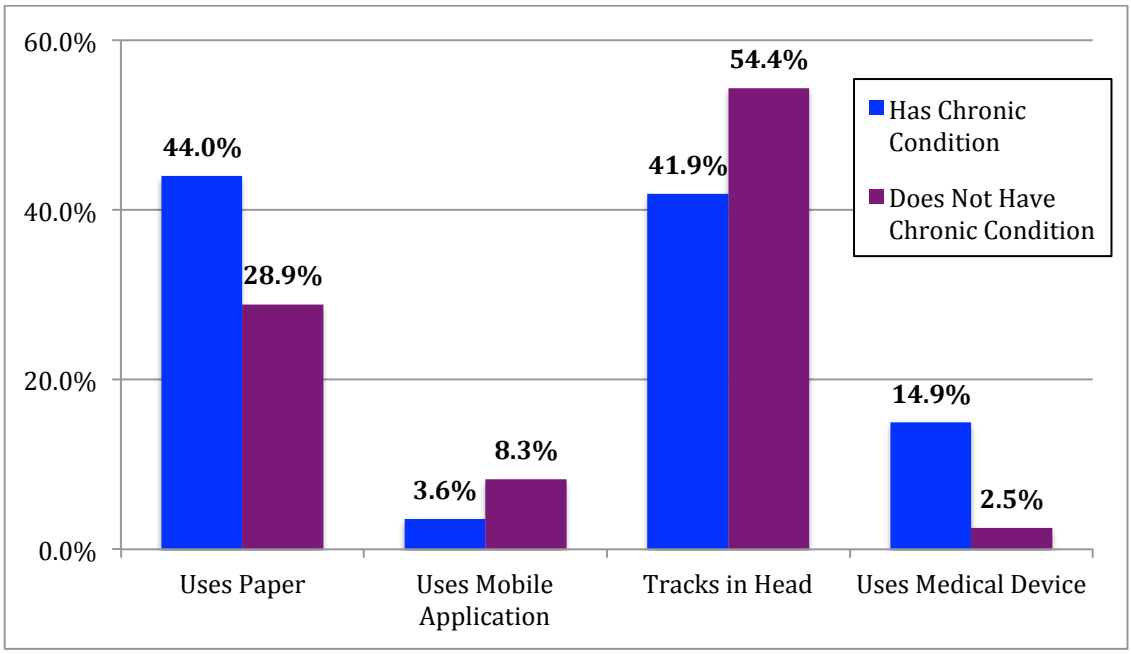

FIGURE 3.5: Tracking by Device Type

Specialty medical devices and mobile applications were used less frequently. Individuals with chronic conditions were more likely than individuals without chronic conditions to use medical devices. About 14.9% of individuals with chronic conditions and 2.5% of those without chronic conditions reported using medical devices. However, 8.3% of respondents who do not have chronic conditions reported using mobile applications to track health information compared to 3.6% of those with chronic conditions. These lower figures for mobile applications may be due to the lack of applications geared toward tracking indicators that people with chronic conditions would like to track.

LOGISTIC REGRESSIONS AND PREDICTED PROBABILITIES

Logistic regression models were used to determine the odds of specific outcomes. Outcomes of interest include if an individual has at least one chronic condition; if an individual tracks any health indicator; if an individual tracks their diet, weight or exercise; if an individual tracks another health indictor; and if the individual users paper or a mobile application to track health indicators. After the models were compared, predicted probabilities were determined based on the odds ratios found in the logistic regressions for individuals fitting a specific profile.

Independent variables included in each of the models were sex, education, income, age and race. These independent variables are demographic variables that may impact the likelihood that an individual has a chronic disease, if they track their health information, what health information they track, or how they track this information. Additional variables included in the logistic regressions serve as either dependent or independent variables, depending on the model. These variables are presence of a chronic condition; tracks health indicator; tracks weight, diet or fitness indicator; tracks other

health indicator; users paper to track health indicator; uses mobile application to track health indicator; and tracks health indicator in head.

Table 3.3 shows the results of the first logistic regression. This model used demographic variables to determine the odds that an individual within the sample would report having a chronic condition. As expected, as income increased, the odds of reporting a chronic condition decreased. A similar pattern is seen with education. Likewise, the age variable showed an expected result. As age increases the odds that an individual reports a chronic condition increases as well. For example, someone over the age of 65 has 1,251% higher odds of reporting a chronic health condition than someone who is 18 to 29 years old.

Variables	Odds Ratios
SEX	
Female	1.16 (0.11)
EDUCATION	
High School	0.82 (0.15)
Some College	0.83 (0.16)
College+	0.68** (0.13)
INCOME	
$30,000 - 49,999	0.77** (0.10)
$50,000 - 99,999	0.48*** (0.06)
$100,000+	0.46*** (0.07)
AGE	
30 to 49	2.45*** (0.38)
50 to 64	7.24*** (1.14)
65+	13.51*** (2.26)
RACE	
Black	0.99 (0.13)
Hispanic	0.63*** (0.09)
Other	0.98 (0.19)
Constant	0.41*** (0.09)
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1	

TABLE 3.3: Odds Ratio of Having a Chronic Health Condition

Sex	Female	Female	Female
Education	College+	College +	College+
Income	$60,000	$60,000	$31,000
Age	35	67	67
Race	White	White	White
Predicted Probability	27.4%	67.6%	76.9%

TABLE 3.4: Probability of Having a Chronic Condition

Table 3.4 shows a predicted probability of different individuals reporting a chronic health condition. All three predicted probabilities modeled use white females with a college degree. A 35-year-old, white female with a college degree with a household income of $60,000 a year has a 27.4% probability of reporting a chronic health condition. However, a 67-year-old woman with the same profile has a predicted probability of 67.6%. A 67-year-old woman with the same profile, but a household income of $31,000 a year has a 76.9% probability of reporting a chronic health condition. These predicted probabilities bolster the findings that older individuals are more likely to report living with chronic health conditions than younger individuals. Furthermore, they indicate that household income is associated with the presence of chronic health conditions. It is possible that household income could be affected by chronic health conditions, as these chronic conditions may prevent individuals from working higher wage jobs. Likewise, those who already have lower incomes may develop chronic conditions due to lack of access to healthcare, healthy food options and exercise activities.

After learning about the likelihood that individuals within the sample have a chronic health condition, logistic regressions were performed to determine the likelihood that those with or without chronic health conditions track health information. Table 3.5 shows that as education, income and age increase, the odds of an individual tracking

health information also increase. Furthermore, individuals with chronic health conditions have 69% greater odds of tracking health information than individuals who do not have chronic health conditions. This is to be expected, as certain types of chronic conditions, such as diabetes and high blood pressure, require individuals to monitor certain health indicators very closely.

Variables	Odds Ratios
SEX	
Female	1.13 (0.11)
EDUCATION	
High School	1.47** (0.25)
Some College	1.94*** (0.36)
College+	1.86*** (0.35)
INCOME	
$30,000 - 49,999	1.44*** (0.19)
$50,000 - 99,999	1.53*** (0.21)
$100,000+	1.60*** (0.26)
AGE	
30 to 49	0.75** (0.10)
50 to 64	0.94 (0.14)
65+	1.64*** (0.28)
RACE	
Black	1.49*** (0.21)
Hispanic	0.94 (0.13)
Other	0.84 (0.16)
HEALTH	
Has Chronic Condition	1.69*** (0.18)
Constant	0.84 (0.18)
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1	

TABLE 3.5: Odds Ratio of Tracking Health Information

The odds ratio indicating that individuals with more education and those with higher household incomes are more likely to track health information is perplexing as Table 3.3 showed these individuals being less likely to report living with chronic health

conditions. Table 3.6 breaks the types of tracking individuals reported into two categories. In the tracks diet, weight or exercise column, as education, income and age increase, the odds that individuals track this information increases as well. However, in the tracks other health indicator column, although the odds ratios increase as age and education increase, as income increases, the odds ratio decreases. Also, individuals with chronic health conditions have 254% greater odds than those without chronic conditions of tracking other health indicators, compared to only 9% greater odds of tracking diet, weight or exercise information.

Variables	Tracks Diet, Weight or Exercise	Tracks Other Health Indicator
SEX		
Female	1.14 (0.10)	0.89 (0.08)
EDUCATION		
High School	1.61*** (0.27)	0.99 (0.18)
Some College	2.19*** (0.38)	1.21 (0.22)
College+	2.26*** (0.41)	1.11 (0.21)
INCOME		
$30,000 - 49,999	1.34** (0.16)	1.32** (0.17)
$50,000 - 99,999	1.53*** (0.19)	1.07 (0.14)
$100,000+	1.68*** (0.26)	0.77 (0.12)
AGE		
30 to 49	0.72** (0.10)	1.10 (0.17)
50 to 64	0.84 (0.12)	1.46** (0.23)
65+	1.52*** (0.24)	1.89*** (0.31)
RACE		
Black	1.17 (0.15)	1.71*** (0.21)
Hispanic	0.91 (0.12)	0.93 (0.14)
Other	0.74 (0.14)	1.02 (0.21)
HEALTH		
Has Chronic Condition	1.09 (0.11)	3.54*** (0.36)
Constant	0.72 (0.15)	0.19*** (0.04)
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1		

TABLE 3.6: Odds Ratio of Tracking Health Information by Type of Information Tracked

The information in Table 3.7 appears to clarify the phenomenon in Table 3.6 where the odds of health information tracking increases as income and education increase. Individuals with higher incomes and more education are more likely to be tracking diet, weight or exercise than those with lower incomes, but they are less likely to be tracking other health indicators. This fits with the findings from Table 3.3 as individuals with higher incomes and more education are less likely to have chronic health conditions and individuals with chronic health conditions are more likely to be tracking other health indicators that are not diet, weight and exercise.

Sex **Education** **Income** **Age** **Race** **Chronic Condition**	Female College+ $60,000 35 White No	Female College + $60,000 67 White No	Female College+ $60,000 35 White Yes	Female College+ $60,000 67 White Yes	Female College+ $31,000 67 White Yes
Predicted Probability					
Tracks in General	66.9%	81.6%	77.4%	88.3%	87.6%
Tracks Diet, Weight or Exercise	67.3%	81.4%	69.1%	82.6%	80.6%
Tracks Other Health Indicator	18.0%	27.4%	43.8%	57.3%	62.4%

TABLE 3.7: Probability of Tracking Health Information by Type of Information Tracked

To illustrate the probability that individuals track health information, several predicted probabilities were created. Much like Table 3.4, the individuals in Table 3.7 are all white females with a college degree to help simplify the comparisons and to show the impacts of chronic conditions, age and income. When considering individuals without chronic conditions, their probability of tracking other health information is low at 18.0% for a 35-year-old with a household income of $60,000 and 27.4% for a 67-year-old with the same income. However, these individuals have a high probability of tracking diet,

weight or exercise information. The same 35-year-old has a 67.3% probability of tracking diet, weight or exercise information and the 67-year-old has an 81.4% probability.

The predicted probabilities for individuals with chronic conditions are similar to those without chronic conditions when comparing their probabilities to track diet, weight and exercise. A 67-year-old white female with a college degree and a household income of $60,000 and a chronic condition has an 82.6% probability of tracking health information related to diet, weight or exercise, and an individual with the same profile, but a household income of $31,000 has an 80.6% probability.

However, the individuals with chronic conditions see much higher probabilities for tracking other health indictors than those without chronic conditions. The 35-year-old in Table 3.7 with the chronic condition has a 43.8% probability of tracking other health indicators. The 67-year-old who has a household income has a 62.4% probability.

The next set of logistic regressions investigates the types of devices these respondents used to track these different types of health information. The three tracking devices options explored are paper, in head and mobile applications. Table 3.8 displays the odds ratios related to tracking diet, weight and exercise, while Table 3.9 includes the odds ratios for other health indicators. Table 3.10 shows the predicted probabilities for using each of the three tracking devices according to the type of health indicator being tracked. The predicted probability table (Table 3.10) provides the best insight into the outcomes from this section of data analysis.

In Table 3.8, the individuals who do not have chronic health conditions have the highest predicted probabilities for the in head tracking method in both categories. They also have higher probabilities of tracking health information in their heads than individuals with chronic health conditions. Likewise, individuals with chronic conditions have higher probabilities of tracking both types of heath information on paper than

individuals who do not have chronic health conditions. Furthermore, using paper to track health information is the device category with the highest predicted probabilities for individuals with chronic conditions regardless of the type of health information being tracked.

Variables	Paper	In Head	Mobile Application
SEX			
Female	1.64*** (0.19)	0.77** (0.08)	1.09 (0.24)
EDUCATION			
High School	0.99 (0.25)	1.15 (0.28)	0.50*** (0.17)
Some College	1.18 (0.30)	1.03 (0.25)	0.95 (0.25)
College+	0.93 (0.24)	0.88 (0.22)	BASE
INCOME			
$30,000 - 49,999	1.26 (0.19)	0.80 (0.12)	1.42 (0.50)
$50,000 - 99,999	1.05 (0.16)	0.91 (0.14)	1.51 (0.51)
$100,000+	0.72* (0.14)	0.98 (0.17)	2.38** (0.87)
AGE			
30 to 49	1.24 (0.23)	0.88 (0.15)	0.55** (0.15)
50 to 64	1.37 (0.26)	0.86 (0.15)	0.10*** (0.04)
65+	1.27 (0.25)	0.90 (0.16)	0.04*** (0.03)
RACE			
Black	1.31* (0.20)	0.68*** (0.10)	0.70 (0.24)
Hispanic	1.14 (0.20)	0.65*** (0.11)	1.15 (0.35)
Other	0.77 (0.21)	1.13 (0.27)	0.54 (0.27)
HEALTH			
Has Chronic Condition	1.78*** (0.22)	0.66*** (0.08)	1.29 (0.32)
Constant	0.23*** (0.22)	1.80** (0.49)	0.16*** (0.32)
Observations	1,551	1,551	1,456
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1			

TABLE: 3.8: Odds Ratio by Type of Tracking Device – Diet, Weight and Exercise

Finally, although the predicted probabilities for using mobile applications to track health information are relatively low, younger individuals have higher predicted probabilities of using mobile health applications. Also, if individuals are tracking other health indicators and they have chronic health conditions, then the probability that they

will use a mobile application to track health information is about twice that of their counterparts without chronic conditions.

Variables	Paper	In Head	Mobile Application
SEX			
Female	2.09*** (0.30)	0.55*** (0.08)	0.71 (0.27)
EDUCATION			
High School	1.20 (0.33)	0.73 (0.20)	2.01 (2.24)
Some College	1.69* (0.48)	0.53** (0.15)	2.89 (3.19)
College+	1.28 (0.37)	0.52** (0.15)	4.04 (4.46)
INCOME			
$30,000 - 49,999	0.88 (0.17)	1.11 (0.21)	2.56* (1.31)
$50,000 - 99,999	0.99 (0.20)	0.92 (0.19)	1.11 (0.67)
$100,000+	0.76 (0.20)	1.11 (0.29)	3.30** (2.00)
AGE			
30 to 49	1.02 (0.28)	0.90 (0.24)	0.27*** (0.13)
50 to 64	1.23 (0.34)	0.69 (0.18)	0.04*** (0.03)
65+	1.42 (0.39)	0.75 (0.20)	0.02*** (0.02)
RACE			
Black	1.20 (0.22)	0.75 (0.14)	1.50 (0.70)
Hispanic	1.56* (0.37)	0.57** (0.14)	1.19 (0.67)
Other	0.69 (0.24)	0.85 (0.29)	0.49 (0.52)
HEALTH			
Has Chronic Condition	1.85*** (0.32)	0.50*** (0.09)	2.89** (1.30)
Constant	0.22*** (0.08)	3.36*** (1.18)	0.03*** (0.03)
Observations	888	888	888
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1			

TABLE 3.9: Odds Ratio by Type of Tracking Device – Other Health Indicator

Sex	Female	Female	Female	Female	Female
Education	College+	College +	College+	College+	College+
Income	$60,000	$60,000	$60,000	$60,000	$31,000
Age	35	67	35	67	67
Race	White	White	White	White	White
Chronic Condition	No	No	Yes	Yes	Yes
Predicted Probability: Diet, Weight or Exercise					
Tracks with Paper	31.0%	31.4%	44.4%	44.9%	52.4%
Tracks in Head	49.3%	49.8%	39.2%	39.7%	36.7%
Tracks with Mobile App	12.3%	1.1%	15.3%	0.6%	0.6%
Predicted Probability: Other Health Indicator					
Tracks with Paper	36.6%	44.6%	51.7%	59.8%	57.1%
Tracks in Head	44.3%	40.0%	28.6%	25.1%	28.9%
Tracks with Mobile App	2.4%	0.2%	6.6%	0.5%	1.2%

TABLE 3.10: Probability of Tracking Health Information by Type of Tracking Device

Finally, after determining that individuals have a lower probability of tracking with mobile applications than they do using paper or simply tracking in their head, sub-samples of the respondents were used to determine if access to mobile technologies increased the odds and subsequently the probability of tracking using a mobile application. Table 3.11 shows the odds ratios for each of these samples. The full sample includes all 2,392 individuals analyzed within the other sections. The owns cell phone sample includes only individuals from the full sample who indicated they own a cell phone of some type, which included 2,084 respondents. Finally, the owns smartphone sample only includes individuals from the owns cell phone sample that said they own smartphones, accounting for a total of 1,079 respondents. The substantially lower odds individuals 50 to 64 and 65+ have of using mobile applications to track their health information really stick out in these logistic regressions.

Table 3.12 includes the probabilities that individuals from each sample will track health information via a mobile application. In all cases, as the sample sizes decrease and

a higher percentage of individuals have access to the necessary technology, the probability that individuals will track health information with a mobile application also increases. For example, a 35-year-old, white female with a chronic health condition who has a college degree and household income is $60,000 a year has a probability of using a mobile app of 10.1% in the full sample, but 14.8% in the sample of users with smartphones. Likewise, a woman with the same profile, but 67-years-old has a probability of 1.1% in the full sample and 6.4% in the sample of individuals who have smartphones.

Variables	Full Sample	Owns Cell Phone	Owns Smartphone
SEX			
Female	1.13 (0.24)	1.11 (0.24)	0.98 (0.22)
EDUCATION			
High School	3.86 (4.03)	3.61 (3.77)	2.23 (2.37)
Some College	8.63** (8.91)	7.99** (8.26)	4.19 (4.39)
College+	8.16** (8.45)	7.47* (7.74)	3.86 (4.05)
INCOME			
$30,000 - 49,999	1.70 (0.55)	1.60 (0.52)	1.94* (0.71)
$50,000 - 99,999	1.76* (0.57)	1.61 (0.52)	1.66 (0.59)
$100,000+	2.68*** (0.93)	2.41** (0.83)	2.09* (0.81)
AGE			
30 to 49	0.54** (0.14)	0.55** (0.14)	0.65 (0.17)
50 to 64	0.11*** (0.04)	0.12*** (0.04)	0.19*** (0.08)
65+	0.05*** (0.03)	0.06*** (0.04)	0.26** (0.15)
RACE			
Black	0.75 (0.24)	0.73 (0.24)	0.60 (0.20)
Hispanic	1.06 (0.32)	1.05 (0.32)	0.80 (0.26)
Other	0.60 (0.27)	0.59 (0.26)	0.49 (0.22)
HEALTH			
Has Chronic Condition	1.20 (0.29)	1.24 (0.30)	1.33 (0.33)
Constant	0.01*** (0.01)	0.01*** (0.01)	0.03*** (0.03)
Observations	2,392	2,084	1,079
Standard errors displayed in parentheses *** p<0.01, ** p<0.05, * p<0.1			

TABLE 3.11: Odds of Tracking with a Mobile Application by Given Sample

The data explored through these logistic regressions and resulting predicted probabilities give a lot of insight into who has chronic health conditions, what types of health information they track, and how they track this information. Individuals who are less educated, those with lower household income, and older individuals have greater odds of living with chronic health conditions. Regardless of the presence of a chronic condition or not, as age increases, so too do the odds that an individual will track health information in general.

Sex	Female	Female	Female	Female
Education	College+	College +	College+	College+
Income	$60,000	$60,000	$60,000	$60,000
Age	35	35	67	67
Race	White	White	White	White
Chronic Condition	No	Yes	No	Yes
Predicted Probability				
Full Sample	**8.6%**	**10.1%**	**09%**	**1.1%**
Owns Cell Phone	**8.7%**	**10.6%**	**1.1%**	**1.3%**
Owns Smartphone	**11.5%**	**14.8%**	**4.9%**	**6.4%**

TABLE: 3.12: Probability of Tracking Health Information with a Mobile Application by Given Sample

Overall, the data suggest that people track different health information given their education, income, and whether or not they have a chronic condition. People who are more educated and those with higher incomes have higher odds of tracking health information in general information. When parsing the health information individuals track into two categories, individuals with more education as well as those with higher household incomes have higher probabilities of tracking diet, weight and exercise information, whereas individuals with lower incomes and individuals with chronic conditions are more likely to track other health indicators.

It appears that age and the presence of a chronic condition have the most influence over which type of device is used to track health information. Individuals with chronic health conditions have higher probabilities of using paper to track health information, and those without chronic health conditions have a higher probability of tracking this information in their heads. Younger individuals are more likely to track health information using mobile devices than their older counterparts, regardless of the presence of a chronic condition.

Finally, when comparing ownership of mobile technology using different samples, it appears that when individuals have access to the mobile platform necessary for tracking their health information, they have a greater probability of using that technology to track their health information. Given the increasing number of smartphone owners in the United States since this information was collected in 2012, it is likely that the predicted probabilities of individuals tracking their health information with mobile applications would be greater today. Furthermore, these results could help assure mobile health application developers that as the smartphone user base increases, so does the probability that individuals will use mobile applications to track health information.

LIMITATIONS

There are a couple of limitations to keep in mind when considering the data collected by the Pew survey. The two main limitations are the age of the survey and the method for contacting participants.

The age of the data collected within this survey is a limitation. In many cases, a survey from 2012 may be a good indicator of what is occurring in 2014. However, several changes have taken place in the smart phone and mobile application markets since the survey was conducted that might have major impacts on the results. The greater

overall use of mobile applications by adults and the widespread use of smart phones could show increased rates of adoption for mobile health applications. Furthermore, increased use of these applications over the past year and a half may show more precise patterns on who is using mobile applications to track health indicators and what health indicators they are tracking.

The second limitation addresses how participants in the survey were contacted. All of the participants were contacted via phone, with 1,808 participating via landline and 1,206 participating via a cell phone. However, more tech-savvy participants may have been more likely to participate in the survey if it were conducted via email or another online method. In the future, it may be wise to consider reaching out to some of the participants via an online method.

Chapter 4: Available on the Mobile Health App Market

There are many health-tracking mobile apps available on the marketplace today. It is important to not only understand who is using health-tracking apps, but what apps are offered, how they work and what population they are intended for. Several health applications currently on the market were chosen and analyzed for these reasons. Each app chosen was from a different health-tracking category. The mobile apps explored are MyFitnessPal, Nike+, Glucose Buddy and T2 Mood Tracker. Each mobile app was explored for price, availability and features to learn what these popular apps offer and help inform future app development.

WEIGHT LOSS/DIET/FITNESS: MYFITNESSPAL

MyFitnessPal is listed as a health and fitness application within the iTunes Store ("Calorie Counter" 2014). This application was developed for both iOS and Android devices. Both the mobile application and browser-based platform are free to users. Their revenue streams are based on external investment and advertising. As of August 2013, MyFitnessPal had over 40 million members worldwide, though their daily logins are much lower than this (Cornstock 2013).

MyFitnessPal includes several features aimed at helping individuals track their calories and stay on track to meeting their overall weight and fitness goals. The app includes a large food database with over 3.8 million pre-populated options, and an exercise database that adjusts calories burned to the time a user performs a given activity ("Lose Weight" 2014). Users can also add their own foods, recipes, meals and exercises. The app remembers the most frequently entered and most recently entered food and exercises, which allows for quicker input of common entries ("Calorie Counter" 2014). MyFitnessPal has an open API that allows for other app developers to integrate with the

MyFitnessPal platform. Several integrations are available with widely used health and fitness tracking apps and devices such as Runtastic, FitBit Tracker, MapMyRide, and The Withings Wi-Fi Scale ("Featured Apps" 2014).

In addition to the calorie counter aspect of the app, users can create goals and track their progress. Data visualization features showing health stats and weight are available ("Calorie Counter" 2014). Furthermore, MyFitnessPal gives users access to an online community where they can connect and share their profiles with friends, meet new people, and converse about a wide variety of forum topics such as recipes, success stories and motivation ("Message Boards" 2014).

WEARABLE ACTIVITY TRACKERS: NIKE+ ECOSYSTEM

Nike+ is a health and fitness mobile app with a wearable activity tracker called the Nike+ Fuelband. Additionally, users can also use the Nike+ accelerometer shoe inserts to track their movements (Cornstock 2013). The Nike+ app was created for iOS and Android devices ("Products" 2014). In August 2013 it was reported that Nike+ had 18 million users (Cornstock 2013). The Nike+ Fuelband SE costs between $149-$169 from the Nike Shop ("Nike Store" 2014). The Nike+ app is free ("Nike+ FuelBand" 2014).

Most of the features available with Nike+ focus on fitness tracking and social interaction. Push notifications that create alerts on the smartphone serve as workout reminders. Intensity tracking and rewards help encourage the user to work hard during their workouts. Social features like the ability to follow and compete with friends, share progress and images with friends, and an app-wide leaderboard help motivate the user ("Nike+ FuelBand" 2014).

DIABETES MANAGEMENT: GLUCOSE BUDDY

Glucose Buddy is an app developed specifically for individuals with diabetes and is listed as a medical mobile application in the iTunes Store. It is also lauded as the number one rated diabetes management mobile app ("Glucose Buddy" 2014). According to their website, over 100,000 individuals use Glucose Buddy to track their blood glucose levels ("Glucose Buddy App" 2014). The basic app is free, but includes advertising. Users can spend $3.99 to remove advertising and an additional $3.99 to add on weight and blood pressure tracking and management options ("Glucose Buddy" 2014).

The Glucose Buddy app contains features that are focused on tracking diabetes-related health indicators and helping users manage their chronic condition. The most prominent feature of the app is the health logs. Individuals can track their blood glucose levels, medications, food, and exercise ("Glucose Buddy App" 2014). Push notifications display reminders to record information into the logs and take medications ("Glucose Buddy" 2014). Furthermore, users can also use the data visualization feature to track their information over time ("Glucose Buddy App" 2014). The app allows individuals to printout health information for their doctors and to access the Glucose Buddy community to trade recipes, connect with other diabetics and learn about disease management ("Glucose Buddy" 2014). Glucose Buddy also offers the option of integrating the app with their calorie tracker ("Glucose Buddy App" 2014).

MENTAL HEALTH: T2 MOOD TRACKER

The T2 Mood Tracker was originally developed for military service members by the National Center for Telehealth and Technology. Now, the application is available to the general public to track mood and evaluate mood changes (Barba 2013). Six mood scales are pre-loaded into the application for tracking purposes. These scales include

anxiety, stress, depression, brain injury, post-traumatic stress, and general well-being ("T2 Mood Tracker" 2014).

Individuals rate their moods through the use of scales. Reminders are available to encourage the users to track their mood. Notes can be added to record daily events, new treatment, and updates in medication that might be affecting mood. Data visualization and data export help individuals see their daily change in mood and allow them to share this information with their health care providers ("T2 Mood Tracker" 2014).

Chapter 5: Recommendations for App Development and Dissemination

Future health-tracking mobile app development should be concentrated on those with chronic illness. As shown in chapter 3, individuals who have chronic conditions have higher odds of tracking health information that is not related to diet, weight or exercise. However, apps that track therapy-specific information targeted toward individuals with chronic conditions only account for about 12% of the apps available on the market (Aitken and Gauntlett 2013). To meet this need, developers should work to create apps that will fulfill the needs of individuals with chronic health conditions.

These apps should be relatively easy to use, so individuals feel comfortable using them. Especially important when developing these mobile apps are the older average ages of individuals with chronic conditions and the higher likelihood that these individuals may have one or more impediments to daily living. Beyond development of the applications, determining a way for disseminating the application is vital due to the large health-related mobile apps market. Additionally, future research pertaining to wearable technology and employer-based incentives for health tracking should be considered.

APP DEVELOPMENT

The goal of the app development portion of the recommendation section is to make suggestions for creating a mobile application to suit different individuals with different chronic illnesses and those with multiple chronic conditions. This app should be flexible enough to allow the user to customize some aspects of the app to their needs, but provide a good deal of structure so it is still easy to use and useful for a wide variety of individuals.

Mobile applications targeted toward individuals with one or more chronic condition should keep their target market in mind. These individuals tend to be older

individuals. They may be less familiar with smartphones than younger adults, which may lead them to feel uncomfortable adopting mobile app technology. Furthermore, about 25% of adults with chronic conditions also face limitations on daily living (Anderson 2010). This may make using smartphones to track their health indicators more difficult. An easy to understand user interface (UI) can help alleviate fears these individuals have and allow them the ability to access additional features available on mobile applications that do not exist when tracking health information on paper or in one's head.

The application's UI should allow for quick data entry, easy to understand options and relatively few steps for most tasks. Individuals who wish to further customize their experience might need to take a bit more time to explore the platform and setup additional features. For an app with the main purpose of tracking health indicators for individuals with chronic illness, these options should be front and center.

During app setup, individuals should be asked which chronic illnesses they are concerned with tracking. The list could include several pre-defined diseases and their relevant health information such as diabetes and blood glucose levels, hypertension and blood pressure, and depression and mood. Each of these indicators would be displayed on the screen immediately when users access the app, encouraging them to log their metrics according to a tracking schedule they choose.

The user could also add on additional indicators they would like to track such as tobacco-use, water intake, diet, exercise, and weight. For those individuals tracking their weight, diet or exercise via other applications, an open API would allow for integrations with these apps, much like the integrations available with MyFitnessPal.

Additional features would be to help with the individual's chronic condition management. These features should help both enable the user to adhere more effectively to their treatment and allow them to become better informed about their disease. Some

features that might meet these goals are notifications, data visualization, printable reports, a social community and a resource database.

An important feature for disease self-management would be a reminder option. With this option, the user could enable push notifications that would remind them via a message on their smartphone that they need to record an indicator, take a specific medication, or that they have an appointment the following morning. This could help the individual with adherence to a treatment regimen.

Data visualization of metrics will allow individuals to track their progress on meeting specific goals such as weight loss for those whose chronic condition may be less severe if they dropped a few pounds. Additionally, it might help the user or their doctor detect patterns that might exacerbate their symptoms. For example, everyday after breakfast the user records a spike in the blood sugar and they happen to be eating a specific cereal. Perhaps changing the cereal will help maintain a constant blood glucose level. These data visualization options could also come with downloadable and printable reports to email doctors or take along paper copies to appointments.

The final two features would help to inform the user. Access to a social community could allow users to meet others with the same chronic conditions they have, solicit advice and talk about their conditions. A resource database could be a go to guide for users on how to manage their conditions. This database could have multiple categories broken down by disease.

APP DISSEMINATION

There are hundreds of mobile health applications available for chronic condition management, and even more available for fitness, diet, and weight tracking. Raising awareness about the app among individuals who do not normally use mobile apps or

smartphones will require more effort than simply listing the app in the iTunes Store and on Google Play (the store for Android apps). Physicians and caregivers are two potential avenues for disseminating information about the app to older adults with chronic conditions. Providing physicians with information about the app and how it could help their patients, would allow them to "prescribe" or recommend the app to their patients. Alternatively, outreach and advertising aimed at caregivers could emphasis the ability for their loved ones to better manage chronic illnesses through the use of the app.

FUTURE RESEARCH

The emergence of wearable technology (wearables) may help address some of the usability issues surrounding mobile applications, as well as increase treatment adherence. Wearables such as Nike+, Jawbone, Fitbit, and the much anticipated Apple watch have the potential to track more than just fitness information. In addition to activity and fitness tracking, potential uses for wearable tech that might benefit individuals with chronic conditions include monitoring vital signs such as blood pressure, pulse, and glucose, tracking sleep patterns and delivering drugs (Walker 2013). These technologies could be combined with mobile applications to provide more robust and accurate tracking of health-related activities and information.

Employer-sponsored wellness programs and wellness incentives for employees are becoming more common. According to a study by RAND, about 50% of employers now offer a wellness program of some sort (Mattke et al. 2013). Of those who offer wellness programs, 79% offer nutrition and weight management programs, which often include tracking related health information (Mattke et al. 2013). As a result, routine tracking is likely to become more common as more employer, insurance companies and schools initiate such programs.

Outcomes from these wellness programs and related incentives could be beneficial for creating programs and mobile applications for individuals with chronic health conditions. Particularly important would be researching how participants in these programs react to the incentives offered to them, and investigating if treatment and tracking adherence increases due to these incentives. Results from investigating this topic could be used when devising a plan of how to disseminate a mobile health app targeted toward users with chronic health conditions.

Chapter 6: Conclusion

About half of the American population is expected to be living with at least chronic condition by 2030 (Anderson 2010). Seniors are much more likely than younger individuals to have chronic health conditions. About 90.7% of seniors reported having a chronic health condition in 2006 (Anderson 2010). It is important that individuals with chronic conditions are able to manage their health and perhaps even treat underlying factors of their illnesses. Individuals with chronic health conditions have a higher probability of tracking and recording health information than those without chronic conditions.

Mobile applications can be used to help these individuals track their health information and better manage their chronic conditions. Currently most of the mobile applications on the market designed to track weight, diet and fitness information. Applications developed specifically to treat chronic conditions may help to increase the ability of individuals to track their health information and improve treatment adherence. However, applications for specific therapy areas account for only 12.2% of the mobile applications on the market today, most of which are targeted toward individuals with chronic conditions (Aitken and Gauntlett 2013).

Even fewer mobile health applications are developed for specifically for seniors despite the higher prevalence of chronic conditions within this population. This is likely due to low rates of smartphone ownership and mobile application usage among these individuals. However, the number of seniors who own smartphones is growing. A mobile application targeted toward seniors with one or more chronic conditions should be developed to meet the needs of this population. It is essential that this application includes an easy to understand UI so older adults who might not be particularly tech

savvy feel comfortable with the technology. Additionally, future research should be conducted to determine the impact wearables have on health information tracking and chronic condition management. If this technology proves successful and easy to use, it could be combined with a mobile application to allow individuals with chronic conditions to collect more accurate health information.

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